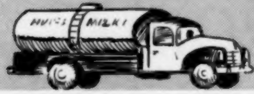
CORNELL EXTENSION BULLETIN 899 

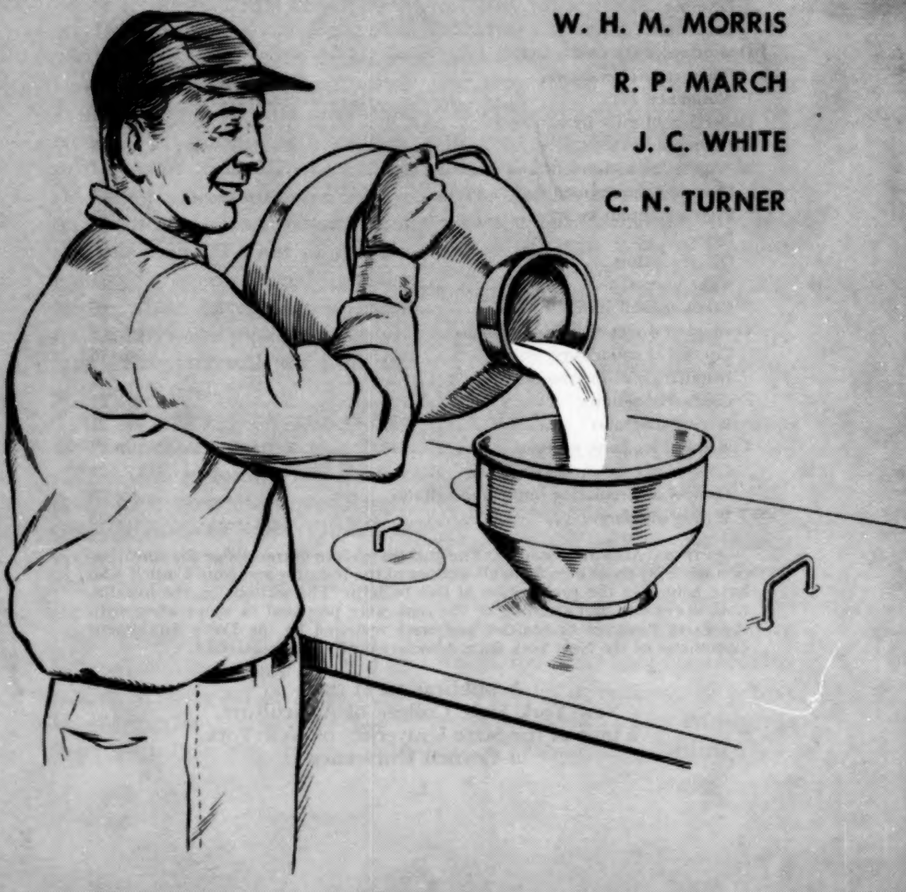
BULK COOLING and STORAGE of milk on the farm

W. H. M. MORRIS

R. P. MARCH

J. C. WHITE

C. N. TURNER



Contents

Authors' Acknowledgment. The authors wish to acknowledge the contribution made by those men from all sections of the industry and from Cornell who have helped in the preparation of this bulletin. The sections on the installation, operation, and cleaning of the tank were prepared in cooperation with the Farm Practices Committee and were reviewed by the Dairy Equipment Committee of the New York State Association of Milk Sanitarians.

A publication of the
New York State College of Agriculture,
a unit of the State University of New York,
at Cornell University

Bulk Cooling and Storage of Milk on the Farm

W. H. M. Morris, R. P. March, J. C. White, and C. N. Turner

This bulletin describes bulk cooling and storage of milk on the farm. The first part gives general information on selection, installation, operation, and cleaning the tank on the farm; and the second part includes technical information on refrigeration, controls, and wiring.

A farm milk tank (figures 1 and 2), designed to cool and store milk on the farm, consists of a stainless steel liner in an insulated housing. On the top of most tanks is a bridge, on which the agitator motor is usually mounted. The rest of the top is closed by covers hinged from the bridge; these have holes in them for strainers or a pipe line. All surfaces in contact with the milk are of stainless steel.

At present, the capacity of the tanks commonly used ranges from 100 to 1000 gallons; a few smaller tanks have been made, and larger ones are made to order. Either the bottom or the sides of the tank or both serve as cooling surfaces for the milk.

To hasten cooling, the milk is agitated. A more rapid method of cooling is achieved in some tanks by distributing the milk so that it flows in a thin film down a cold wall of the tank (figure 3). The cooling surfaces of the tank are chilled either directly by the refrigerant, commonly Freon 12 (figure 1) or by water, which is in turn cooled by a bank of ice (figure 2).

Farm milk tanks are supplied either as a "packaged unit" or with the condensing unit separate from the tank (figure 4).The term *condensing unit* refers to a refrigerating unit that consists of the compressor, the condenser, and the receiver. It should not be confused with the term *condenser* which is one of the three parts of the unit.

Selection of the Tank

The size and production of the herd and the tank-truck pickup schedule determine the size of the tank needed. For everyday pickup, the tank should hold at least two milkings during peak production. When the pickup schedule is every-other-day, the tank should hold at least four peak milkings. Every-other-day pickup is, however, not practiced in all areas. On some milk routes, the tanks have been selected for three peak milkings to permit every-other-day pickup during the period of low milk production.

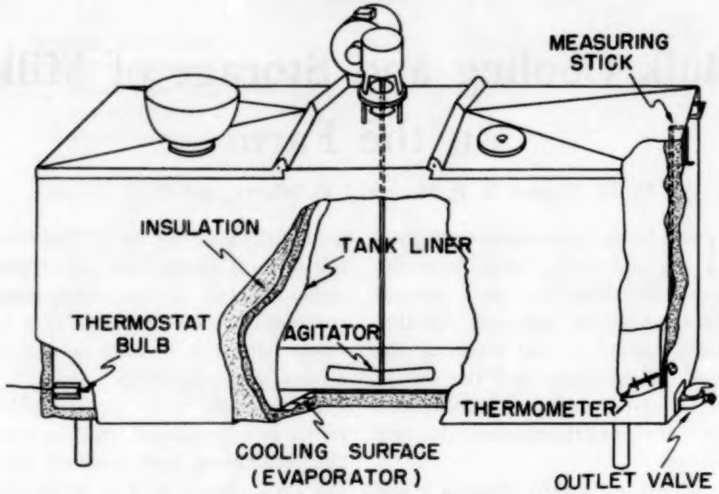


Figure 1. Direct-Expansion Tank

A condensing unit (figure 4) is connected to the evaporator of this tank on the farm.

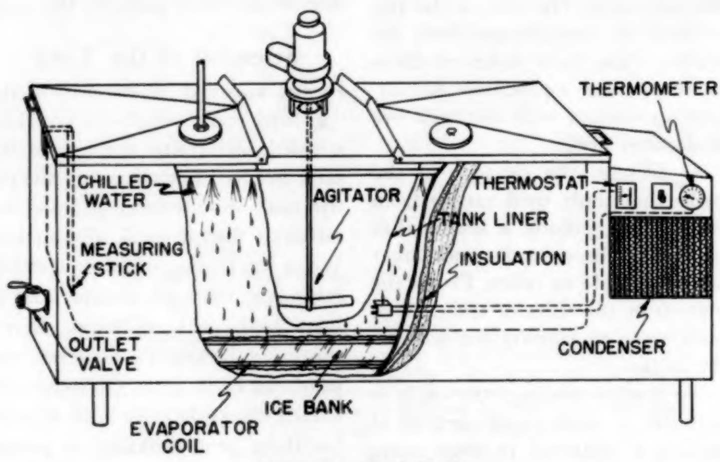


Figure 2. Ice-bank Tank

The chilled water pump (not shown) circulates water from the ice bank over the outside surface of the tank line.

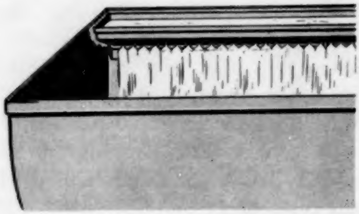
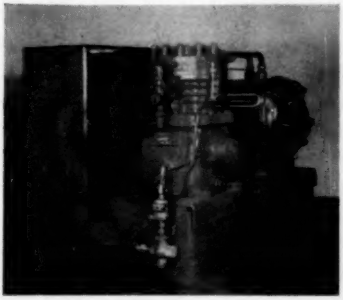


Figure 3. Flash Cooling of Milk

The milk entering the tank flows in a thin film down the cold refrigerated wall and thus is rapidly cooled.

This type could be used with the direct-expansion tank in figure 1. This unit is a combination air-and-water-cooled type. Note the water regulating valve in the foreground of the left picture. The right-hand picture shows the Freon receiving tank and the water-cooled condenser. The end plates on this condenser are removable to permit periodic cleaning. This unit has been turned on its side to show the water-cooled condenser.



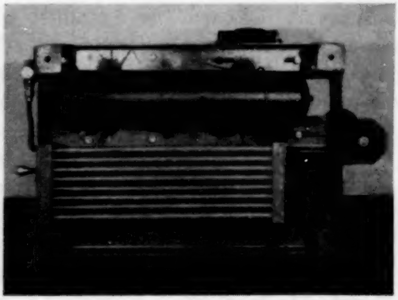


Photo from Girton Mfg. Co.

Figure 4. Condensing Unit

Kinds of Systems

Two major types of cooling systems are available: (1) the direct-expansion and (2) the ice-bank. Either may be selected and installed to cool milk satisfactorily.

Direct-expansion system

The *direct-expansion* system using an air-cooled condenser (figure 1) requires about 1 horsepower of compressor motor capacity for each 50 gallons of milk to be cooled at each milking. Slightly less horsepower is needed with water-cooled condenser units. Therefore, each horsepower provides greater cooling capacity with a water-cooled condenser than with an air-cooled condenser. The direct-expansion system operates during each milking period and from one-half to two hours thereafter. This requires a large motor on the condensing unit to cool the milk during the short period of operation. Direct-expansion cooling of the milk requries accurate and reliable thermostatic control to prevent the milk from freezing. The size and efficiency of the condensing unit directly affects the rate of cooling.

While the large condensing unit represents a high initial cost, studies show that the total electric consumption averages about 0.9 kilowatt hour for each 100 pounds of milk cooled. This consumption is usually less when water is used in the condenser.

The direct-expansion system, with a relatively large compressor motor, requires additional expense for electric service, including larger wires and switches for the milk house and possibly for the barn. Large motors also increase the demand for electric power at the time of day when there are many other demands for power.

Ice-bank system

The *ice-bank system* with an air-cooled condenser (figure 2) requires about 1/3 horsepower of compressor motor capacity for each 50 gallons of milk to be cooled at each milking. Again, water-cooled condensers increase the efficiency of the unit, but they are not often needed with the smaller compressors used on the ice-bank systems. Since a smaller condensing unit is used, it must operate more hours each day to rebuild the ice bank between milking periods. The electric consumption for these systems usually is higher (about 1.6 kilowatt hour per 100 pounds) than for the direct-expansion system partly because of the operation of the water-circulating-pump motor.

The purchase price of the ice-bank coolers, however, is usually less than that for the direct-expansion system and the electric wiring installation costs also are usually a little lower. Since chilled water is used for cooling, there is no possibility of the milk freezing.

The condensing unit on the ice-bank coolers operates over a long period of time. This provides an opportunity to utilize the heat from the condenser to warm the milk house, especially important at night. It supplements other sources of heat to keep the milk house dry and to keep water from freezing in the pipes. On the other hand, the direct-expansion coolers produce heat over a short period of time when the operator is most likely to be in the milk house; an advantage in the cold months, a possible disadvantage in summer.

The size or the efficiency of the condensing unit on the ice-bank coolers does not directly affect the rate of cooling milk. Once the ice bank has been formed, the water circulation, and not the operation of the condensing unit, controls the time required to cool milk to the desired holding temperature.

For cooling milk with an ice-bank cooler in an emergency, such as during a power failure, a standby electric generator about one-third the size of that required for the direct-expansion type is satisfactory.

Packaged or Separate Units

The ice bank and the smaller sizes of direct-expansion tanks are made in "packaged" units. These are easier and cheaper to install.

The larger direct-expansion coolers are usually purchased with the tank and condensing units separate. These are assembled and installed on the farm. Separate units can be installed so that the heat can be directed inside or outside the milk house, depending on the time of the year.

Before deciding which kind of bulk-cooling system to select one should carefully weigh all the advantages and disadvantages in the light of his own particular circumstances.

Location of the Tank

The following points should be considered in locating the tank in the milkhouse.

1. When bucket milkers are used, the tank should be as near to the barn door as is convenient. The straining holes in the covers should be placed to require a minimum of walking to pour the milk into the tank; on tanks of more than 150-gallon capacity this can usually be achieved by interchanging the covers. The holes should be so located that it is not necessary to stand in front of the outlet valve to pour milk into the strainer.

2. The tank should be at least 2 feet from any wall for ease in cleaning and for the maintenance of the tank. Any major passageway past the tank should be at least 3 feet wide. Where pipeline milkers are used, more space may be needed for cleaning special equipment, such as the releaser, the air separator jar, and the pump.

3. If the sides of the tank are high, a two-level floor in the milk-house saves much effort in pouring milk from the pails into the tank.

4. The outlet of the tank should be towards the trap-door or toward some other door through which the milk hose passes to the truck. The distance from the outlet to the pump on the tank truck should not be longer than the length of hose to be carried on the truck, preferably from 8 to 12 feet; auxiliary pipe or hose should never be kept on the farm. The maximum length of a section of hose is governed by the washing facilities at the dairy plant.

5. The drainage of wash water from the outlet of the tank should run into a separate drain in front of the tank and to the side of the outlet. For sanitary reasons there should be no drain directly under the tank or its outlet.

6. Where a pipeline milking system is used, one should be able to observe the discharge end of the pipe line and the tank from the milking area; a window in the wall is a practical arrangement for this. It reduces the chance of milking with the end of the pipe line out of place or of running wash water into the milk tank.

Condensing Units

Location and Ventilation

To insure satisfactory and economical operation, the condensing unit must have an adequate supply of cool air. Water-cooled units need only enough ventilation to cool the

motor, but air-cooled and combination air- and water-cooled units require a generous amount of cool air.

Since the efficiency of the condenser decreases unless it is kept free from dust, it should be cleaned periodically.

The exhaust air from the condenser should be directed away from the tank; this reduces the deposition of dust and dirt on or in the tank. Adequate provision must be made to exhaust this air from the milkhouse during warm weather.

Packaged units

With packaged units, the condensing unit is mounted with the tank and, therefore, its location is governed by the location of the tank. For this reason tanks with air-cooled units (as are most packaged units) must be so placed that there is enough space for air to circulate around the condenser. The minimum clearance of 2 feet (page 7) should easily fulfill this requirement. In warm weather adequate ventilation can usually be provided by natural circulation of air through screened louvres, windows, or doors.

Adequate ventilation may be determined in terms of the can type of milk cooler. For example, if the horsepower of the bulk-tank unit is about the same as that of the can cooler previously used (assuming one was removed) and there was no cooling difficulty then, probably there will be no cooling problems with the bulk-tank unit. If, however, the horsepower of the bulk-tank unit is considerably larger, as it would be with a direct-expansion system, then care must be taken to prevent condenser air temperatures from becoming too high. Higher condenser temperatures increase both the cooling period and the cost of operation.

If natural ventilation is inadequate, forced ventilation may be necessary. A fan with a louvre, wired to operate at the same time as the compressor, will ventilate the milkhouse. The fan should be able to move 450 cubic feet of air per minute per horsepower of the compressor motor. In cold weather the fan should be shut off, as the heat from the condenser helps to warm the milkhouse.

Separate unit inside the milkhouse

A separate condensing unit inside the milkhouse should be mounted off the floor to reduce the circulation of dust and to keep the unit away from water. The requirements for ventilation are similar to those for packaged units; but since separate units are usually placed with the condenser near the wall, a screened louvre should be installed in the wall in front of the condenser to permit most efficient operation. The condenser should be about 6 inches from any wall, to permit circulation of air around it in cold weather when the louvre is closed.

The best location of the louvre is on a shaded side of the milkhouse, away from other buildings, to enable the greatest movement of air. The louvre should be at least 18

inches above ground level, and the area outside should be relatively free from dust which might be drawn into the milkhouse. Grass cover on this area helps to keep down the dust.

Separate unit outside the milkhouse

A condensing unit mounted outside the milkhouse should be protected from the weather by a shelter with an air intake and exhaust opening, each with an area at least as large as that of the condenser. The location of the intake should be the same as that described in the preceding paragraphs. In designing a shelter, accessibility for servicing the unit should be kept in mind.

In very cold weather, it may be necessary to restrict air flow through the condenser to permit proper operation of the condensing unit. This should be done only when the unit is protected by a high-pressure safety cut-out.

The installation of the condensing unit outside the milkhouse may be arranged so that the warm air can be circulated through the milkhouse in cold weather and discharged outside at other times.

Special care must be taken to prevent freezing damage to condensing units that use water for cooling.

Water Cooling

The efficiency of air-cooled condensing units decreases with a rise in air temperature. For this reason, with an adequate supply of good water, it is usually advisable to install combination air- and water-cooled units to ensure the most efficient operation under summer temperatures. Units of 5 horsepower and larger are usually cooled entirely by water. When the temperature of the air at the condenser falls below 32°F., there is danger of damage to the water system by freezing. The water supply for combination air- and water-cooled units should, therefore, be shut off and all parts of the water system drained during winter. Care should be taken to remove water trapped in such locations as the bowl of the water-regulating valve. Sometimes it is necessary to blow the water out of the system with compressed air. Units cooled entirely by water must be protected from freezing.

For water-cooled and combination air- and water-cooled units, the flow of water is controlled by the head pressure of the refrigeration system and by the setting of the water-regulating valve. When a water-cooled unit starts, the head pressure opens the water-regulating valve and the water flows; further increase in head pressure increases the flow of water. When the compressor stops, the flow of cooling water is also stopped. The water consumption of water-cooled condensing units ranges from 0.5 to 2.0 gallons per minute per horsepower. It is difficult to give specific figures for the water consumption of combination air- and water-cooled units because the water condenser is supplementary, functioning only when

the air condenser cannot carry the load by itself. The water-regulating valve on combination units is usually set to be opened by a head pressure of 100 to 130 pounds per square inch as measured by a gauge (p.s.i.g.).

On farms with an inadequate water supply, cooling water might be conserved and subsequently re-used for washing equipment or for watering stock. Water consumption can also be reduced by lowering the temperature of the expended warm water with a cooling tower which makes it possible to re-use the cooled water in the condenser. A small pump is required to circulate this water. Another type of water-cooled condenser that uses a relatively small amount of water is the evaporative condenser.

Water-cooled condensers need periodic cleaning to remove deposits of water scale. The frequency of cleaning depends upon the degree and type of hardness in the water. In areas where the water is very hard or corrosive, the use of water condensers may be impracticable.

In installations where combination air and water-cooled units are not suitable or are not wanted, extra-large capacity air-cooled condensers are available. The initial and operating costs of air condensers are, however, higher for the larger units than for those that use water.

The condenser should always be mounted as near to the compressor as possible. If vibration of the pipes is troublesome, flexible connections should be used at the compressor.

Truck pump-motor outlet

The electric outlet must be suitable for the plug on the extension cord that goes to the pump motor on the tank truck. It is recommended that this outlet be of the 3-pole, 230-volt, twist-lock type and that it be placed near the outside milkhouse door where the truck stops. If this outlet is mounted outdoors, it should be a weather-proof receptacle.

Lights

Lights should be positioned to illuminate the interior of the tank when the covers are open, to facilitate measuring the milk and cleaning the tank. The lights should be placed beyond the outer edge of the tank to prevent any dust on the lights from falling into the milk.

Location of Electrical Controls and Outlets

Tank control panel

The control panel should be in the milkhouse near the tank or on the tank of the packaged unit. Each of the switches should be clearly labelled to prevent mistakes by those who have to use them.

Installation of the Tank

Leveling

The tank should be placed in position and leveled by screwing the legs up or down until a spirit-

level placed on the breasts of the tank shows it to be level. Some tanks have fittings for a plumb bob, enabling one to level the tank without a spirit-level. A tank that has been calibrated before leaving the factory may have four leveling marks inside the tank. These help to assure more precise leveling because they can be used as a gauge of the water level when one is adjusting the legs of the tank. The bottom of the tank after it has been leveled should be at least 6 inches from the floor.

Tanks without legs should be sealed with a waterproof compound to a level concrete platform a few inches high on the floor of the milkhouse.

Calibration

The tank may need to be calibrated after installation; this is generally arranged by the field man from the milk plant or cooperative. It should be done in the presence of the farmer. In New York State it is not, at present, necessary to have the calibration checked by the Bureau of Weights and Measures, although this may be required in the future.

After calibration, the location and level of the tank should be fixed. Grouting the legs to the milkhouse floor prevents movement and in some cases changes in level by rotation of the legs. Recessing the legs into the milkhouse floor is not advised because it weakens the floor. Changes in level can also be prevented by applying wire seals to the legs. Calibration marks, scribed near each of the four inside corners, or a plumb bob enable one to check easily to ensure that the level of the tank is unchanged.

Operation of the Tank

The producer and all those who are to operate the tank should be familiar with the manufacturer's instructions.

Shortly before placing any milk in the tank, the control should be set for automatic operation. It should remain on automatic while milk is in the tank. As soon as some warm milk enters the tank, the thermostat starts the cooling unit. The milk then is cooled to the control temperature which is about 38°F.; if the milk temperature rises a few degrees, the unit cools the milk down again to the control temperature.

This procedure cannot be used satisfactorily for the second or subsequent milkings unless the cooling system is started by a maximum of a 4-degree rise in temperature of the milk in the tank. With a rise of more than 4 degrees, there will be an excessive delay before cooling starts; so this system should be turned on manually at the start of the milkings. The control should be set for automatic operation at the end of the milking; otherwise, in direct-expansion tanks, the milk may freeze. The possibility of freezing milk in this way can be eliminated by the use of a start button on the thermostat or a mechanical

timer. *The cooling system should not be started by changing the setting of the thermostat.*

If the milk freezes when it first enters an empty tank, the cooling system has been turned on too soon. Such a system should not be started until there is from 20 to 30 quarts of milk in the tank.

On most tanks the agitator control can be set for automatic operation from the beginning of milking, so that the agitator starts at the same time as the cooling system. On other tanks it is necessary to wait until the blades are covered before turning on the agitator, to prevent excessive splashing of the milk. The agitator should be turned on as soon as possible, since it greatly speeds the cooling of the milk.

Before the addition of the second milking and before subsequent milkings where the milk is collected every other day, the agitator may be turned on manually. This blends the cream layer and the milk already in the tank. It also prevents the warm milk entering the tank from collecting in a layer, which would retard the automatic starting of the cooling system. The *agitator control* should be set for automatic operation as soon as convenient after the thermostat has cut in, to prevent the possibility of churning the milk (page 21). This may be done automatically by a mechanical timer for the agitator motor.

Another way to blend the milk and cream and to prevent the warm milk from collecting in a layer is the use of a start button on the thermostat or of a mechanical timer that controls both the agitator and the condensing unit or the agitator and the circulating pump.

Emergency operation

Some provision should be made to cool the milk should there be a power failure.

Stand-by generating equipment is a practical solution. The size of the generator required to start the compressor motor is usually adequate to operate the entire cooling system. Approximately 2 kilowatts of generator capacity are required for each horsepower of compressor motor size. Ice-bank systems can be arranged so that only the condensing unit or the agitator and circulating pump operate at one time. A group of farmers with large condensing units might use the same portable, tractor-driven generator to cool their milk at different times. Both engine-driven and tractor-driven generators are described in Cornell Extension Bulletin 879, *Emergency Equipment for Electric Power Failures.*

It may be possible to drive a belt-driven compressor with a belt from a tractor, using a countershaft if necessary. In this case the milk has to be agitated manually. A solenoid valve in the installation must permit manual operation of the valve.

The warm milk might be hauled to the milk plant after each milking, provided the milk plant has adequate facilities to cool the milk

and provided the milk pump on the tank truck can be operated.

Performance

FARM milk tanks should be able to cool the milk to 50°F. within the first hour after the completion of milking and to 40°F. by the end of the second hour. This is the minimum rate of cooling required by the 3A[1] standards for farm bulk milk tanks.

Many of the manufacturers have engineered their tanks for more rapid cooling, which reduces the danger of churning the milk. Milk churns easily under severe agitation if the fat in the milk is soft, which it is likely to be during the cooling period. Below 40°F. the danger of churning is negligible unless the agitator is accidentally left on manual control and continues to operate between milkings.

Some tanks, used more commonly on the West Coast, accomplish almost instantaneous cooling by distributing the milk in a thin film running over a cold wall of the tank (figure 3).

Some tanks are designed solely for every-other-day pick up; that is, they can cool one-fourth of their capacity at one milking period. These tanks are unsuitable for daily pick up at their rated capacities because they will not be able to cool one-half of their capacity in the prescribed time. A tank with a cooling capacity sufficient only for every-other-day pick-up should not be purchased if it may eventually be used to cool more than one-half of its total capacity each day.

The satisfactory performance of the tank should also include holding the milk within plus or minus 2 degrees of the desired storage temperature (40°F.).

Collection of Milk by the Hauler

AFTER stopping the tank truck near the milkhouse, the hauler checks the odor of the milk in the farm tank. The low storage temperature of the milk reduces the intensity of odors, but strong off-odors can be detected even when the milk is cold. The hauler then measures the depth of milk in the tank while the milk is at rest. If it is necessary to wipe the measuring rod, a sanitized (clean and approximately sterile) cloth or a new filter pad should be used. The agitator is then switched on to mix the milk before sampling; this may require from 3 to 5 minutes, depending upon the size of the tank and the design and speed of the agitator. While the milk is being mixed, the driver brings the sample dipper and the composite sample bottle into the milkhouse; he also uncoils the milk hose from the truck, removes the cap and sanitizes the end of the hose and the outlet valve, and couples the hose to the farm tank. He then plugs the extension cord

[1]Formulated by the International Association of Milk and Food Sanitarians, U. S. Public Health Service, and the Dairy Industry Committee.

from the electric pump on the truck into the outlet provided.

When the milk has been thoroughly agitated, the hauler takes a sample and adds it to the composite bottle carried on the truck. At the farmer's request a duplicate sample may be left on the farm. The truck sample is stored under refrigeration and the farm sample should be stored in a cool place.

The milk is then pumped out of the farm tank into the tank truck. When the farm tank has been emptied, the milk hose is uncoupled from this tank, capped, and replaced on the truck, and the extension cord for the truck milk pump is rewound on its reel. The hauler then rinses the farm tank completely, closes the milkhouse door, and drives away.

Cleaning Farm Tanks

Special cleaning brushes are essential with each tank. They should be stored in a metal cabinet or hung from brackets on the wall near the tank.

As soon as the farm tank has been emptied, the truck driver should rinse it with cold or luke-warm water. This water should be supplied under pressure through a short hose equipped with a self-closing nozzle. A thorough job of rinsing is one of the most important steps in the cleaning procedure because it should remove nearly all of the milk soil.

The tank should be washed as soon as possible after rinsing. The agitator and all other detachable fittings, such as thermometers, strainers, and outlet valve plug, should be removed; then the inside surfaces of the tank and covers are brushed with a 110° to 120°F. solution of a good dairy cleaner made in accordance with manufacturer's directions. All the removable parts are brushed in the same solution. After brushing thoroughly, the equipment is rinsed and reassembled. It is preferable to rinse with water at 110° to 120°F.

Just before the tank is to be used, the outlet valve is closed and the tank is sanitized with a chemical sanitizer made in warm water according to manufacturer's directions. The inside surfaces and the covers are sprayed or brushed with this solution. The tank is then drained thoroughly. The solution may be used for sanitizing other equipment.

Refrigeration Equipment and Controls

Electrical requirements

Synthetic rubber or thermo-plastic-covered non-metallic sheathed cable should be used for milkhouse wiring. Conduit is not recommended because condensation may collect within the tubing and cause rapid corrosion. The correct wire size should be used to ensure adequate voltage as well as current-carrying capacity. The bulk cooler should be on a separate branch circuit with the correct wire size and proper fuse protection. Wire and

fuse sizes are given in Cornell Extension Bulletin 849, *Adequate Farm Wiring Systems.* Magnetic starters and switches should be of the correct horsepower ratings for the motors they control. Safety switches used for motor controls must be horsepower rated; and if fuses are used, they should be of the proper sized time-delay type for adequate overload protection of the motors.

Compressor motors, ½ horsepower or larger, should be run on a 230-volt power supply. Agitator motors, pump motors, and solenoid valves can be obtained to run on either a 115- or a 230-volt supply. The higher voltage is better because: smaller wires can be used; all motors start easier; and there is better balance in the electrical system.

Each individual electric motor must have adequate overload protection. This may be built into the motor or starting relay by the manufacturer, otherwise it must be incorporated in the control system by thermal overload devices. With direct-expansion systems, it is also desirable to provide interlocking protection, so that, if the compressor motor is stopped by its protective device, the agitator motor will also stop; if it does not stop, churning of the milk may result. Conversely, if the agitator is stopped by its protective device, the compressor motor will also stop and prevent the milk from freezing. Both motors properly wired provide this interlocking protection (figures 5, 6, and 7). With an ice-bank system, this interlocking protection is necessary so that, if the circulating pump motor is stopped by its thermal overload device, the agitator motor will also stop and prevent the milk from churning (figure 8). Further information on protection for electric motors is given in Cornell Extension Bulletin 673, *Protection for Electric Motors.*

Pressure cutout switches

One horsepower or larger water-cooled or air-and-water cooled condensing units may have a high-pressure safety cutout switch that protects the cooling unit if excessive head pressure is built up. The cutout is set at the factory and the setting should not be changed on the farm. A common factory setting for Freon 12 units is 180 p.s.i.g. Some direct-expansion units with direct thermostatic control, including those with air-cooled condensers have a low-pressure safety cutout which prevents running at very low suction pressures. A common setting ranges from 5 to 25 p.s.i.g. which corresponds to temperatures ranging from approximately –8° F. to 25°F. In very cold weather, a setting of 25 p.s.i.g. may be so high that it prevents the unit from starting. With indirect thermostatic control, a setting of 5 p.s.i.g. is used for cutout and 15 p.s.i.g. for cut-in to control the condensing unit (page 20). This permits pumping the refrigerant out of the evaporator.

Driers

Small amounts of moisture in the refrigeration system can greatly reduce the efficiency and damage the installation. Separate condensing units should have a drier of a suitable size, based on the horsepower of the motor. This maintains the moisture content of the refrigerant at a safe level. The drier is usually installed in the liquid line but it can be in the suction line. In either, a drier with a granular filling should be installed in a vertical or nearly vertical position. If it is on the liquid line, the liquid should enter from the bottom; if on the suction line, the vapor should enter from the top. This reduces the deposition of oil in the drier that causes a reduction in performance. Driers with a molded filling may be installed in any position. The drier should be installed in as cool a place as possible since it may give up moisture if it gets warm. Driers usually incorporate a strainer to prevent material from blocking valves in the refrigeration system.

Oil separators

Sometimes oil separators are installed in the refrigeration system to prevent oil that leaves the compressor from collecting in other parts of the system where it would reduce efficiency. On some farm tanks oil separators are not needed.

The oil separator must not be placed where in cold weather the refrigerant vapor would condense in the separator and then be returned to the base of the compressor and cause trouble. If the condensing unit is placed in the milkhouse where the temperature is kept above freezing, the refrigerant vapor should not condense in the separator.

Sight glasses

A sight glass in the liquid refrigerant line or in the accumulator of a flooded system provides a simple way to check whether the system is short of refrigerant.

Crank-case-oil level

A low oil level in the crank case may indicate that oil is accumulating in other parts of refrigeration systems or that there is a gas leak. Oil should not be added to the crank case without correcting the cause of the loss. The addition of oil should be made by the service man.

Control of Direct-Expansion Systems

Control of condensing units

Satisfactory operation of farm tanks in the cooling of milk requires the accurate control of a sufficient quantity of refrigeration. The condensing unit may be controlled directly by a thermostat or indirectly by low-pressure control.

For *direct control,* the thermostat is wired in series with the coil of a magnetic starter (figures 5 and 6). When the milk is cooled to the desired temperature, the thermostat contacts open and the magnetic

starter stops the compressor motor. When the milk temperature rises a few degrees, the thermostat contacts close and the magnetic starter starts the compressor motor. A liquid line solenoid valve is often installed in parallel with the motor circuit (figures 5 and 6) in refrigeration systems that use a thermostatic expansion valve. This closes the liquid line when the compressor is not running and prevents the possibility of flooding the evaporator with liquid.

When a combination high-low pressure cutout is used and when the head pressure rises or the suction pressure falls below the pre-set limits, the high- or low-pressure switch opens the control circuit, opens the magnetic starter, and stops the compressor and agitator motors. Sometimes only the high- or the low-pressure cutout is installed on the condensing unit.

For *indirect-control* systems, the thermostat is installed to open and close the liquid line solenoid valve (figure 7). When the milk temperature rises a few degrees, the thermostat opens the solenoid valve; the suction pressure rapidly rises, the contacts of the low-pressure control close, and the magnetic starter starts the compressor motor. When the milk is cooled to the desired temperature, the thermostat contacts open; the solenoid valve closes, cutting off the flow of liquid refrigerant to the evaporator. The compressor pumps the refrigerant out of the evaporator into the receiver, lowering the suction pressure until the contacts of the low-pressure control are opened; the magnetic starter then stops the compressor motor.

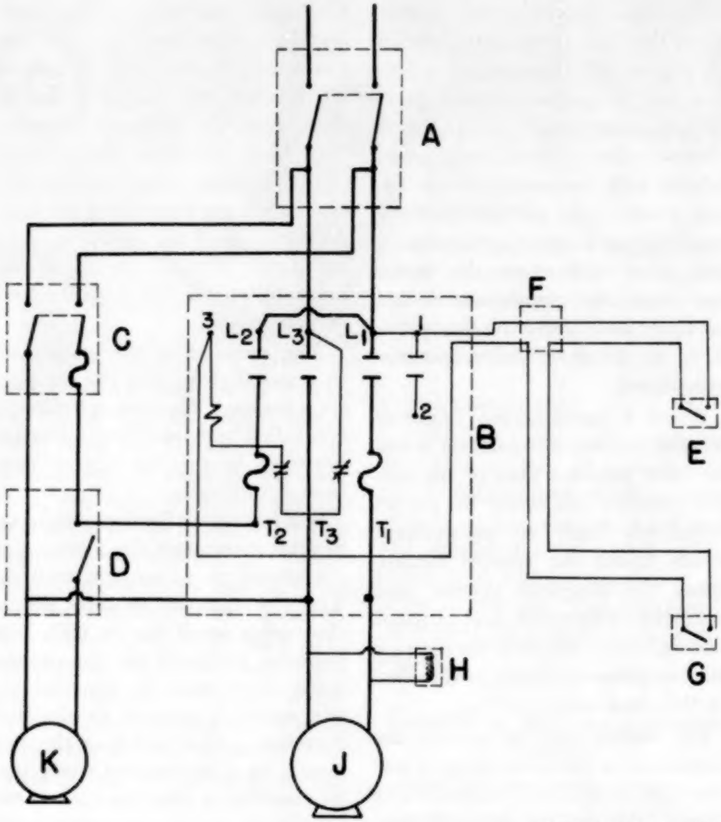
In both the direct and indirect control systems, excessive head pressure causes the contacts of the high-pressure control to open. This opens the control circuit of the magnetic starter and stops the compressor motor.

The pressure in the evaporator increases slightly after the compressor is stopped. This causes indirectly controlled systems when operating normally to run for a very short time at intervals.

It is important for the compressor to start soon after the addition of the second or subsequent milking. The thermostat contacts should close on a small rise in milk temperature and start the compressor. Some thermostats as installed are not sensitive enough to do this; therefore, a start button on the thermostat or a mechanical timer may be installed to close the circuit and to start the compressor motor. Sometimes a manual switch is installed with no timed cut-off. In such an installation there is always a danger that the switch might be left on by accident and then the milk could freeze.

Installation of thermostat

The thermostat controls the temperature to which the milk is cooled. The bulb must be in close contact with the inner liner of the tank to

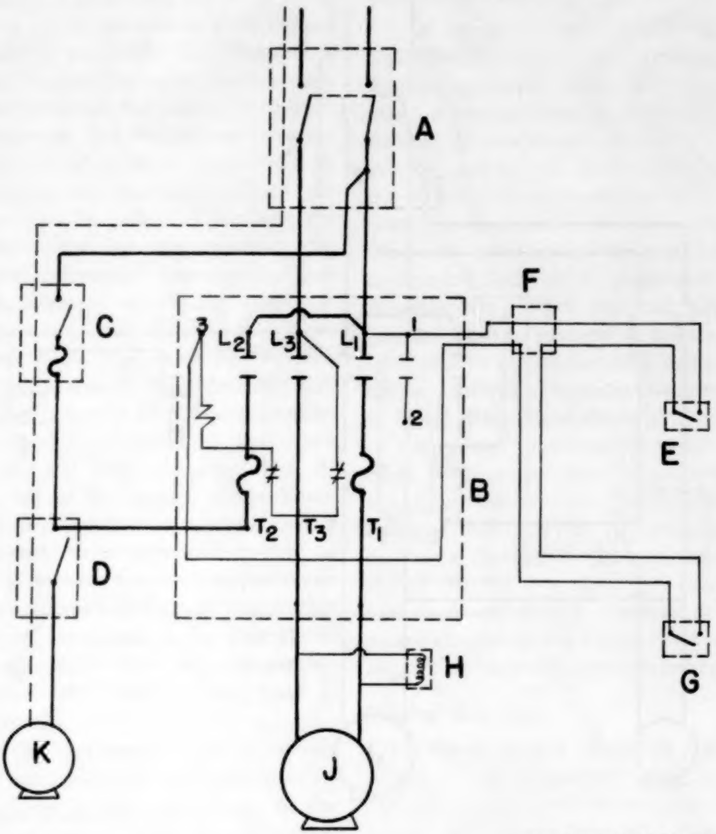


Drawing by Paul E. Steiger

Figure 5. Direct-Expansion System with Direct Thermostatic Control—3-wire, 115/230 volt

(A) 3-pole SN safety switch; *(B)* 3-pole 230-volt magnetic starter; *(C)* SPST thermal overload switch or safety switch with time delay fuse normally open or "off", a mechanical timer may be added to reduce the possibility of churning; *(D)* SPST toggle switch normally closed or "on"; *(E)* thermostat with start button or thermostat and mechanical timer; *(F)* junction box; *(G)* combination high- and low-pressure control; *(H)* 230-volt liquid line solenoid valve — on dry type evaporators only; *(J)* 230-volt compressor motor; *(K)* 115-volt agitator motor.

Note. Thermal overload elements to be rated at not more than 125 percent of full-load running current for protecting 40°C. rise motors and 115 percent for 50°C. rise motors. Higher ratings are allowed as specified by the National Electrical Code for non-hermetically sealed refrigerating compressors.

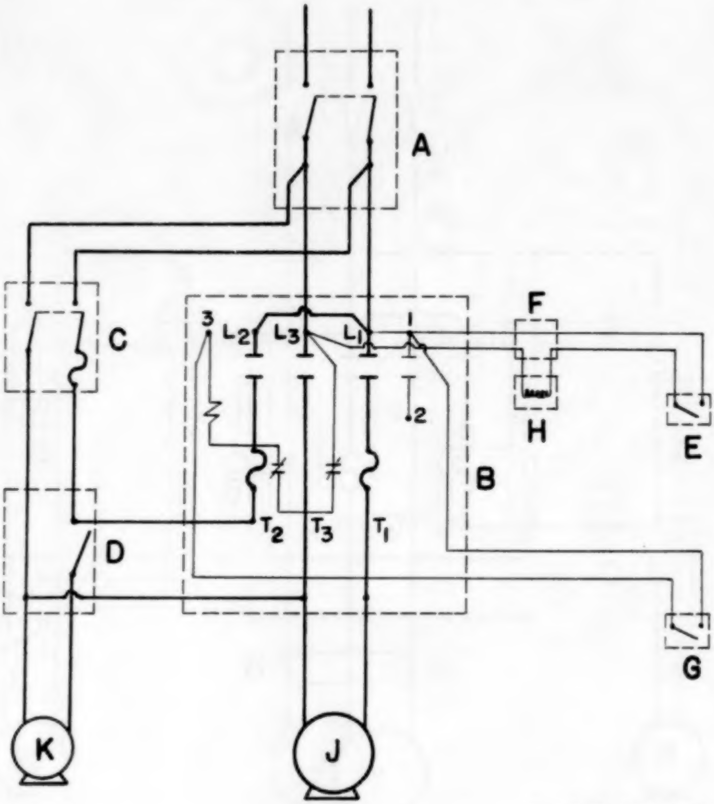


Drawing by Paul E. Steiger

Figure 6. Direct-Expansion System with Direct Thermostatic Control—2-wire, 230 volt

(A) 2-pole safety switch; *(B)* 3-pole 230-volt magnetic starter; *(C)* DPST thermal overload switch or safety switch with time-delay fuses normally open or "off", a mechanical timer may be added to reduce the possibility of churning; *(D)* SPST toggle switch normally closed or "on"; *(E)* thermostat with start button or thermostat and mechanical timer; *(F)* junction box; *(G)* combination high- and low-pressure control; *(H)* 230-volt liquid line solenoid valve—on dry type evaporators only; *(J)* 230-volt compressor motor; *(K)* 230-volt agitator motor.

Note. Thermal overload elements to be rated at not more than 125 percent of full-load running current for protecting 40°C. rise motors and 115 percent for 50°C. rise motors. Higher ratings are allowed as specified by the National Electrical Code for non-hermetically sealed refrigerating compressors.



Drawing by Paul E. Steiger

Figure 7. Direct-Expansion System with Indirect Thermostatic Control—2-wire 230-volt

(A) 2-pole safety switch, *(B)* 3-pole 230-volt magnetic starter, *(C)* DPST thermal overload switch or safety switch with time delay fuses normally open or "off"; a mechanical timer may be added to reduce the possibility of churning, *(D)* SPST toggle switch normally closed or "on", *(E)* thermostat with start button or thermostat and mechanical timer, *(F)* junction box, *(G)* combination high and low pressure control, *(H)* 230-volt liquid line solenoid valve, *(J)* 230-volt compressor motor, *(K)* 230-volt agitator motor.

Note. Thermal overload elements to be rated at not more than 125 percent of full-load running current for protecting 40°C. rise motors and 115 percent for 50°C. rise motors. Higher ratings are allowed as specified by the National Electrical Code for nonhermetically sealed refrigerating compressors.

ensure a minimum lag of temperature at the thermostat bulb behind that of the milk. The thermostat dial should be set at the temperature to which the milk is to be held. Once set the thermostat should not be adjusted to start the condensing unit manually; a start button can be provided to close the thermostat contacts mechanically. The differential between the temperatures at which the contacts open and close should be no more than 4°F.; that is, the thermostat contacts should close when the milk temperature is 2° F. above the control milk temperature and open when the milk temperature is 2° F. below the control temperature. With this differential, the milk can be held at a temperature close to that desired. A wide differential can easily be caused by poor installation of the thermostat bulb. This allows the milk to warm up considerably before the condensing unit is started.

The thermostat must be capable of controlling the cooling system regardless of the temperature of the milkhouse. A thermostat of an unsuitable type may fail to operate or it may operate erratically when the milkhouse temperature is as low or lower than that to which the milk is to be cooled. Mounting an unsuitable thermostat on a cold pipe, such as the refrigerant suction pipe or on a cold wall, may accentuate this effect and the condensation of moisture may damage the instrument.

Control of agitator

The agitator motor should be connected for both manual and automatic operation. Manual control may be accomplished by a thermal switch. A mechanical timer may also be used so that the motor cannot be left on accidentally for a long time, which might churn the milk. On some installations the agitator is controlled by a single-pole, double-throw switch (manual, off, automatic). The purpose of manual control is to agitate the milk before taking a sample or in some instances to blend the milk at the beginning of the second or subsequent milkings. With a thermal overload switch normally left open, the agitator motor is on automatic operation through the magnetic starter (figures 5, 6, and 7). A thermal overload switch protects the motor and serves as a means of turning the agitator off when necessary.

Wiring diagrams

Electrical control diagrams (figures 5, 6, and 7) illustrate how the operations described can be accomplished. Individual overload protection is provided for each motor. A wiring diagram for a 3-wire 115/230-volt system with direct thermostatic control is shown in figure 5. A similar method of control for a 2-wire 230-volt system is shown in figure 6. Indirect thermostatic control for a 2-wire 230-volt system is illustrated in figure 7.

These diagrams illustrate a few of the satisfactory and the least expen-

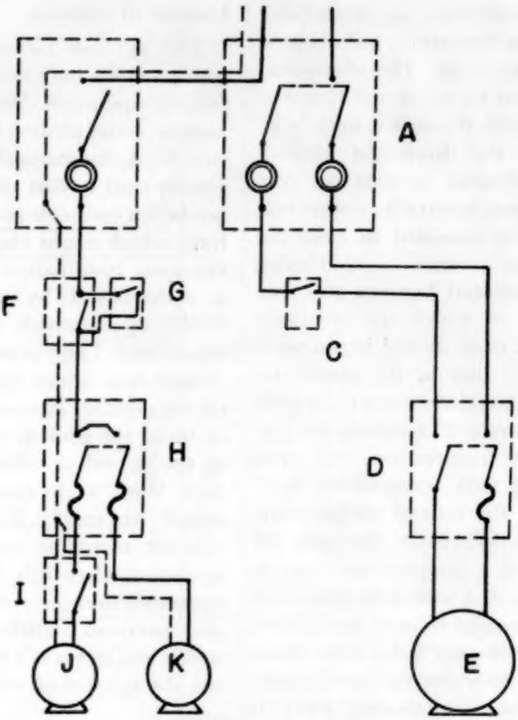


Figure 8. Ice-bank System—3-Wire 115-230 Volt

(A) 3-pole SN safety switch, 115/230 volt; *(B)* 2-pole SN safety switch, 115 volt; *(C)* ice-bank thermostatic control; *(D)* thermal overload switch or "built-in" overload protection on the motor; *(E)* 230-volt compressor motor; *(F)* SPST toggle switch or mechanical timer; *(G)* thermostat for water-circulating pump and agitator motor; *(H)* DPST thermal overload switch for interlocking control and protection on both motors; *(I)* SPST toggle switch, normally closed or "on"; *(J)* 115-volt agitator motor; *(K)* 115-volt water-circulating pump motor.

Note. Thermal overload elements to be rated at not more than 125 percent of full-load running current for protecting 40°C. rise motors and 115 percent for 50°C. rise motors. Higher ratings are allowed as specified by the National Electrical Code for non-hermetically sealed refrigerating compressors.

sive arrangements to control and protect motors used in direct-expansion systems.

Control of Ice-Bank Systems

Control of condensing units

With ice-bank systems, a condensing unit builds an ice bank as in a can cooler. Water, cooled by the ice, cools the milk. A thermostatic control limits the size of the ice bank. The size of the bank can be decreased or increased by moving the bulb towards or away from the evaporator coil to which it is attached. A second ice-bank control may be installed as a safety measure to prevent the freezing of all the water if the operating control should fail. The condensing units are of smaller capacity than those used on tanks of the same size, cooled by direct-expansion refrigeration. With ice-bank systems, the required quantity of refrigeration is obtained by the condensing unit operating for a longer time. The condensing unit should provide enough refrigeration without operating more than 16 hours a day.

Control of circulating pump and agitator

The cooling water is circulated by a pump either through a spray pipe and down the outside of the inner liner or directly under the bottom and around the lower parts of the liner. The milk in the tank is agitated for rapid cooling.

The agitator and the pump are usually controlled automatically by a thermostat (figure 8). When the temperature of the milk rises, the agitator and the pump are started. A manual control is also provided so that the inner liner can be precooled and the milk can be agitated before adding a second milking or before taking a sample. It may also be wired to run the pump with the agitator switched off.

Wiring diagram

The electrical control diagram for ice-bank systems (figure 8) illustrates a satisfactory arrangement for control and overload protection of motors used in ice-bank systems. The arrangement is suitable for a 3-wire 115/230-volt power supply.

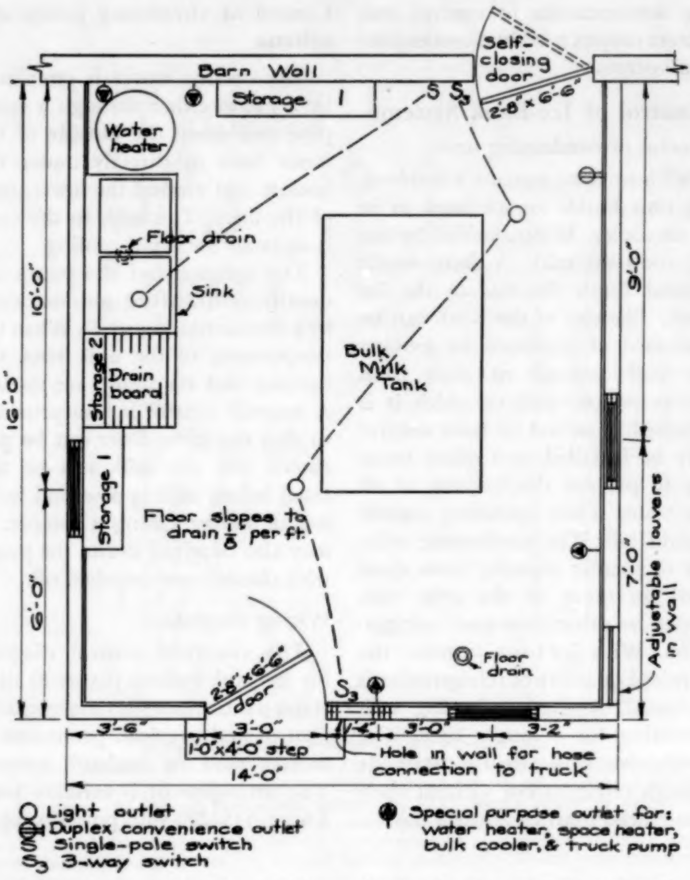


Figure 9. Floor plan of a milkhouse, showing location of milk tank and electric outlets

Adequate storage for equipment is at *1;* cupboard at *2* is for the storage of filter discs, detergents, and sanitizers. If the condensing unit is detached, locate the unit in the corner. If the condensing unit is attached, move the louvers close to the unit. Be sure to place a vapor barrier on the inside wall to protect the insulation. Provide a heater to keep the room temperature at approximately 40° F. This plan was prepared in cooperation with, and approved by, the Department of Dairy Industry at Cornell University and the Farm Practices Committee of the New York State Association of Milk Sanitarians.

Published by the New York State College of Agriculture at Cornell University, Ithaca, New York. L. R. Simons, Director of Extension. This bulletin is published and distributed in furtherance of the purposes provided for in the Acts of Congress of May 8 and June 30, 1914.